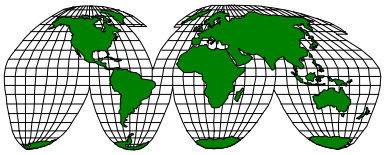
The Global Geodetic Infrastructure - A Framework for ***AFREF***



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Global Geodetic Observing System - GGOS
NASA/Jet Propulsion Laboratory, USA
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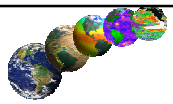
FIG Regional Conference - Accra, Ghana

Introduction



- Geodetic Services of International Association of Geodesy (IAG):
  - IGS, International Earth Rotation and Reference Sytem (IERS) International Laser Ranging Service (ILRS), International VLBI Service (IVS), International DORIS Service (IDS), International Gravity Field Service (IGFS)
  - International Terrestrial Reference System - part of IERS combines solutions of the Services (non-gravimetric) for realizations of ITRF
- Global Geodetic Observing System - GGOS
  - GGOS official participant in ad-hoc Intergovernmental Group of Earth Observations (GEO), and actively engaged in defining the GEO System of Systems (GEOSS) for long term Earth observations.

GGOS Definition

- GGOS - ***Global Geodetic Observing System***
  - Monitors the Earth system as a whole through the IAG components: Services, Commissions, Projects
  - Based on: geometry and kinematics, Earth orientation and rotation, and gravity field and its variability
    - GGOS provides geodesy's and IAG's contribution to Earth sciences and society
    - GGOS integrates the work of IAG and is the bridge to the other geosciences
- Integrated Global Observing System Partnership - IGOS-P with theme - *Earth System Dynamics*
- GGOS - *'Catch the Planet'*

Modern Geodetic Tool - GNSS
The Framework

Global Navigation Satellite Systems

- Principles of navigation, surveying and geodesy remained the same until the Space Age ~1950's
- Celestial and global terrestrial reference systems were established, continually improving
- GPS revolutionizes the field of modern geodesy
  - Enables ready and global access access to the signals
  - Foundation for the civilian exploitation of these systems is one of IAG's key services:
    - *IGS - International GNSS Service* (formerly, International GPS Service)
    - Principles of ***open data policy***
    - Highest quality products available anywhere - GPS and GLONASS

Astronomy, Geodesy, Surveying and Navigation

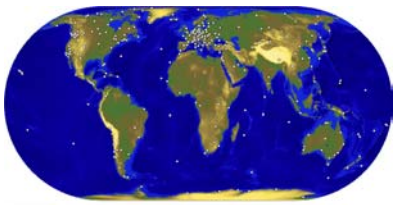
Peter Apian's *Geographia* 1533

Concepts are the same today, GNSS are the 'stars'

Quick answers: What is the IGS?

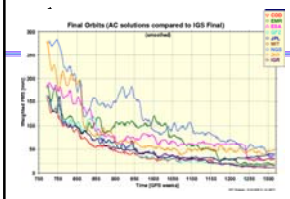
The International GNSS Service (IGS, formerly the International GPS Service) is a voluntary federation of more than 200 worldwide agencies that pool resources and permanent GNSS station data to generate precise GNSS products. Currently the IGS supports two GNSS: GPS and the Russian GLONASS.

Over 350 permanent, geodetic GNSS stations operated by more than 100 worldwide agencies comprise the IGS network.



Civilian, dual frequency receivers tracking L1, L2, P2, and C1 or P2, minimally contributing daily files of 30-sec samples. Sub-network tracking new L2C

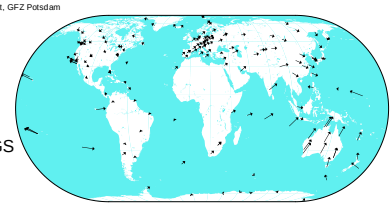
Quick answers: What is the IGS?



Graph courtesy Analysis Coordinator G. Gendt, GFZ Potsdam

IGS products are formed by combining independent results from each of several Analysis Centers. Improvements in signals and computations have brought the centers' consistency in the Final GPS satellite orbit calculation to about 2cm.

Many earth science missions and measurements, and multidisciplinary applications, rely upon the *openly-available* IGS products such as ephemerides and coordinate time series.



United Nations Activities

- Charter for the United Nations Office of Outer Space Affairs - Action Team on Global Navigations Satellite Systems:
  - *"Using space applications for human security, development and welfare, action should be taken … to improve the efficiency and security of transport, search and rescue, geodesy, and other activities by promoting the enhancement of universal access to and compatibility of space-based navigation and positioning systems."*
- Regional Workshops - Lusaka July, 2002, and June 2006
  - AFREF sessions successful
- UN GNSS Report and recommendations finalized December 2004
  - http://www.oosa.unvienna.org/SAP/gnss/index.html
- **International Committee on GNSS (ICG) established in December 2005**
  - Mechanism for coordination and exchange, consensus body
  - IAG and FIG both members of ICG
- Key recommendation resulting from UN meetings --> to realize AFREF
  - (See Wonnacott, et al.)

Surveying & Mapping

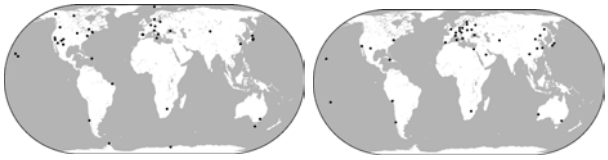
- Surveying: GPS techniques provide a level of 3-D positioning accuracy and timing that is
  - highly efficient, instantaneous (depending on accuracies required, even near-real time at sub-decimeter level), and is very economical compared to conventional optical surveying techniques.
- Mapping: Maps, GIS, SDI, InSAR, photogrammetry - any imaging of the Earth requires
  - a geo-referencing system to be relevant
  - GNSS provides positioning information to relate mapping points or image objects to the local, regional (national) or global reference system, *including* spatial/temporal changes.
- Geoid and vertical datum must be included

Reference Frame & GNSS

- Fundamental benefits of GNSS for Surveying &Mapping
  - Internationally accessible system provides positioning information that is related to the a common global reference frame, e.g., WGS'84 of the GPS, PZ90 of GLONASS all precisely related to the International Terrestrial Reference Frame 2000 (ITRF2000, ITRF 2005 coming soon)
    - WGS'84 is broadcast by the GPS satellites
    - WGS'84 and ITRF2000 have evolved together, and are virtually the same standard, being consistent at the ***few centimeter*** level - GPS has led to the extensive global densification of ITRF

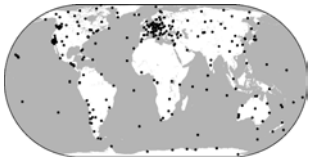
    The ITRF represents analytical rigorous combinations of multiple space geodetic techniques to realize the precise reference system of the Earth (combining VLBI, SLR, GPS, GLONASS, DORIS,…)
  - Maps and GIS tied to a global system (via GNSS) with common standards of SDI can be immediately related *even if independently produced*

Space Geodetic Networks of IVS, ILRS and IGS



VLBI **SLR**

GPS



Considerations

Generalized issues:

- Great need for education and training on GNSS technology and applications for surveying, mapping and Earth science
  - Workshops and in-depth technical exchanges necessary
- Developing nations request assistance to:
  - Procure, implement and operate GNSS equipment, processing *and* communication systems, with emphasis on sustainable systems
  - Establish GPS-based control points, precisely locatable
  - Develop coordinate systems consistent with modern ITRF
    - transformations from national horizontal and vertical datum to modern 3-D national continental datum based on the global reference system - challenging - National Mapping Organizations critical lead here
  - Fully integrate GNSS as the precise geodetic base of SDI for GIS
- All GNSS must operate in identical reference *and* timing systems
  - Interoperability between GPS, GLONASS and future Galileo

Recommendations

- Many national mapping organizations base their fundamental operations now on GPS - this will evolve as GNSS develops
- Governments should therefore be encouraged to:
  - Establish national plans for GNSS with user support groups and access to 'experts', coordinate regionally and internationally
  - Provide for long-term protection of the GNSS signal spectrum through collective action and voice, e.g. interference detection, mitigation and reporting; and World Radio Conferences (WRC) participation
  - Maintain close contact with countries and international organizations (FIG, IAG, ICG,..) which are developing and advocating GNSS technology for geodetic and cadastral surveying, mapping, geological surveys, SDI, GIS, marine navigation, etc.
  - Provide financial incentives that stimulate private investment in GNSS (e.g., reduce or eliminate import taxes)

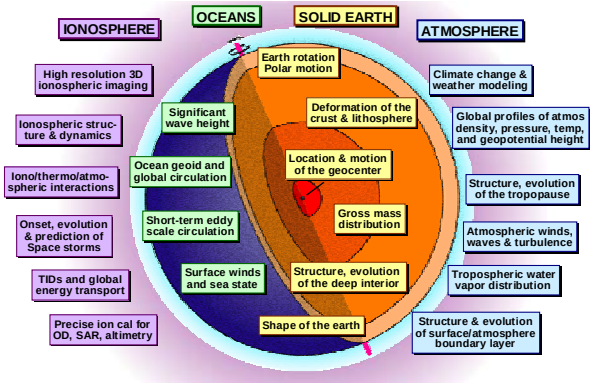
GNSS - Primary Framework for AFREF

- *GNSS technology and many derived applications*
  - *Demonstrate significant positive societal benefit as an accessible, economical tool for nearly all geo-referencing needs*
  - *Bring ability to tap considerable potential related to human life and the environment*
- *AFREF - Unification of African Reference Frames*
  - *can leap-frog development cycle and realize state-of-the-art continental reference system with commitment of African organizations, particularly NMO's, and with dedication of international partners*

Thank-you

Back-up Slides

Probing the Earth with GPS/GNSS



Classic IGS station: short pillar monument, choke ring antenna, desirable VLBI co-location

(Pie Town, NM)

Photo courtesy of D. Stowers, JPL

Photo courtesy ESA/ESOC

Think you can solve for the snow depth from this station's data? (Kiruna, Sweden)

Relocating a station to a better-monumented spot (Thule, Greenland)

Photos courtesy F.B. Madsen, DNSC

Acknowledgements & Notes

IGS is a federation with no central funding authority, each contributor is currently self-funded

It is important to recognize the significant contributions of all organizations worldwide who support and sponsor IGS activities.

Collective vision and dedication prove to be successful and beneficial for all.

WHY IGS? Historical notes

- Geodynamics, geodetic, and space agency organizations realized the potential of GPS by late 1980's
- Motivating goal: *millimeter* positioning in support of science & engineering anywhere in the world
- No single agency can or should assume the capital investment & recurring operations costs for the entire infrastructure
- Join with key international partners to form federation, define cooperation, set standards, driven by science quality
- Global framework for virtually all regional & national network
- Implement a global *civilian* GPS tracking system for science and research
- Participants are enthusiastic!
- Later, more products (tropospheric, ionospheric…) from the same rich data set